

EVALUATION OF ADVANCED R&D TOPICS IN PHOTOVOLTAICS

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Objective

- DEVELOP PRIORITIZED LIST OF ADVANCED R&D AREAS
IN PHOTOVOLTAICS TO ASSURE OPTIMAL USE OF LIMITED
FUNDS.

Approach

- IDENTIFY AR&D AREAS (SERI/JPL/SANDIA PV PROGRAM MANAGERS/RESEARCHERS,
OMB GUIDELINES, SPEAC AND ERAB REPORTS)
- DEVELOP EVALUATION CRITERIA
- SOLICIT EVALUATIONS FROM PV EXPERTS IN INDUSTRY, UNIVERSITIES AND
GOVERNMENT
- EVALUATE RESPONSES; IDENTIFY RELATIVE IMPORTANCE OF AR&D AREAS;
ALLOCATE FUNDING

AR&D Areas

- 35 AR&D ACTIVITIES WERE IDENTIFIED IN 10 MAJOR AREAS:
 - AMORPHOUS SILICON
 - CONCENTRATOR CELLS
 - CRYSTALLINE SILICON
 - HIGH EFFICIENCY: III-V AND RELATED AREAS
 - INNOVATIVE CONCEPTS
 - LUMINESCENT CONCENTRATORS
 - PHOTOELECTROCHEMICAL AREAS
 - SUPPORT RESEARCH
 - SYSTEMS AND MODULES
 - II-VI AND RELATED AREAS

Evaluation Criteria

● CONTRIBUTION TO BASIC SCIENTIFIC UNDERSTANDING:

| | |
|--------------------|--|
| <u>VERY LIKELY</u> | TO PRODUCE SIGNIFICANT ADVANCES, DISCOVERIES,... |
| <u>LIKELY</u> | TO ADD FUNDAMENTAL KNOWLEDGE |
| <u>NOT LIKELY</u> | TO ADD NEW KNOWLEDGE |

● POTENTIAL IMPACT (IN 5 YEARS OR MORE) ON FURTHER TECHNOLOGY DEVELOPMENT BY PRIVATE INDUSTRY:

| | |
|------------------|--|
| <u>EXCELLENT</u> | PROBABILITY OF SIGNIFICANT IMPACT |
| <u>PROBABLE</u> | THAT POSITIVE OR INDIRECT IMPACT WILL RESULT |
| <u>UNLIKELY</u> | TO HAVE ANY IMPACT |

● PRIORITIES FOR FEDERAL AR&D FUNDING:

| | |
|---------------------------|--|
| <u>VERY HIGH PRIORITY</u> | MUST BE FUNDED, REGARDLESS OF TOTAL BUDGET AVAILABLE |
| <u>HIGH PRIORITY</u> | SHOULD BE FUNDED IF POSSIBLE |
| <u>MEDIUM PRIORITY</u> | FUND IF ADEQUATE FUNDS EXIST |
| <u>LOW PRIORITY</u> | FUND ONLY UNDER HIGHEST BUDGET |
| <u>VERY LOW PRIORITY</u> | SHOULD NOT BE FUNDED |

Example

III-V COMPOUND SEMICONDUCTOR MATERIALS FOR HIGH EFFICIENCY PHOTOVOLTAIC CELLS

THIS INCLUDES STUDIES OF NUCLEATION AND GROWTH, DOPANT INCORPORATION, DEFECT DENSITY REDUCTION, LATTICE MISMATCHED GROWTHS, STRESSED LAYERS AND SUBSTRATE DEVELOPMENT. MATERIALS SHOULD INCLUDE BINARY, TERNARY, AND QUATERNARY III-V COMPOUNDS, THIN POLYCRYSTALLINE FILMS AND THIN FILMS ON REUSABLE OR SACRIFICIAL SUBSTRATES.

| | | | | | | |
|--|-------------|------|----------|-----|------------|--|
| CONTRIBUTION TO BASIC SCIENTIFIC UNDERSTANDING | VERY LIKELY | | LIKELY | | NOT LIKELY | |
| POTENTIAL IMPACT ON FURTHER TECHNOLOGY DEVELOPMENT BY PRIVATE INDUSTRY | EXCELLENT | | PROBABLE | | UNLIKELY | |
| PRIORITY FOR FEDERAL AR&D | ERY HIGH | HIGH | MEDIUM | LOW | LOWEST | |

COMMENTS:

Evaluation Summary

- 62 RESPONSES WERE RECEIVED FROM PV EXPERTS IN INDUSTRY, UNIVERSITIES AND GOVERNMENT:
 - 29 INDUSTRY
 - 9 UNIVERSITY
 - 24 GOVERNMENT
- NORMALIZED SCORES WERE CALCULATED BY ASSIGNING VALUES TO QUALITATIVE RATINGS; AREAS WERE RANK-ORDERED FOR EACH EVALUATION CRITERION
- FOLLOWING CHARTS SHOW RANKINGS (1ST THROUGH 35TH) OF AR&D AREAS FOR THE THREE EVALUATION CRITERIA

Amorphous Silicon

| | <u>SCIENTIFIC VALUE</u> | <u>TECHNOLOGY IMPACT</u> | <u>FUNDING PRIORITY</u> |
|--|-----------------------------|------------------------------|-----------------------------|
| LIGHT INDUCED CHANGES IN AMORPHOUS SILICON AND EFFECTS ON SOLAR CELL STABILITY | 1 | 2-3 | 1 |
| INTERFACE PROBLEMS ASSOCIATED WITH AMORPHOUS SILICON PHOTOVOLTAIC DEVICES | 11-12 | 2-3 | 4 |
| DEPOSITION METHODS FOR AMORPHOUS FILMS | 11-12 | 1 | 2 |
| MATERIAL CHARACTERIZATION AND THEORETICAL UNDERSTANDING OF THIN FILM AMORPHOUS MATERIALS | 2 | 7 | 3 |
| NEW AMORPHOUS MATERIALS | 8-9 | 9-10 | 15 |

Concentrator Cells

| | <u>SCIENTIFIC VALUE</u> | <u>TECHNOLOGY IMPACT</u> | <u>FUNDING PRIORITY</u> |
|--------------------------------|-----------------------------|------------------------------|-----------------------------|
| CONCENTRATOR CELL OPTIMIZATION | 28 | 21 | 20 |

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Crystalline Silicon

| | <u>SCIENTIFIC VALUE</u> | <u>TECHNOLOGY IMPACT</u> | <u>FUNDING PRIORITY</u> |
|---|-----------------------------|------------------------------|-----------------------------|
| DEFECT PASSIVATION AND MATERIALS MODIFICATION FOR POLYCRYSTALLINE SILICON | 10 | 8 | 12 |
| BASIC MECHANISMS IN POLYCRYSTALLINE SILICON | 6 | 15-16 | 10-11 |
| CELL PHYSICS IN CRYSTALLINE SILICON | 15-17 | 15-16 | 14 |
| SILICON SOURCE MATERIAL RESEARCH | 29 | 17-18 | 22 |
| SILICON MATERIAL GROWTH | 21 | 4 | 18-19 |

High Efficiency: III-V and Related Areas

| | <u>SCIENTIFIC VALUE</u> | <u>TECHNOLOGY IMPACT</u> | <u>FUNDING PRIORITY</u> |
|--|-----------------------------|------------------------------|-----------------------------|
| III-V COMPOUND SEMICONDUCTOR MATERIALS FOR HIGH EFFICIENCY PHOTOVOLTAIC CELLS | 4 | 12 | 6-7 |
| FUNDAMENTAL STUDIES IN III-V COMPOUND SEMICONDUCTOR MATERIALS AND SOLAR CELLS | 3 | 19 | 10-11 |
| STRUCTURAL ELEMENTS OF HIGH EFFICIENCY PHOTOVOLTAIC CELLS | 15-17 | 6 | 5 |

Innovative Concepts

| | <u>SCIENTIFIC VALUE</u> | <u>TECHNOLOGY IMPACT</u> | <u>FUNDING PRIORITY</u> |
|-------------------------------|-----------------------------|------------------------------|-----------------------------|
| NEW CONCEPTS | 14 | 13-14 | 8 |
| ORGANIC MATERIALS AND DEVICES | 13 | 29 | 30 |

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Luminescent Concentrators

| | <u>SCIENTIFIC VALUE</u> | <u>TECHNOLOGY IMPACT</u> | <u>FUNDING PRIORITY</u> |
|---|-----------------------------|------------------------------|-----------------------------|
| PHOTOCHEMICAL RESEARCH ON LUMINESCENCE IN SOLIDS | 19 | 33-34 | 31-32 |
| LUMINESCENT CONCENTRATORS | 27 | 33-34 | 31-32 |

Photoelectrochemical Areas

| | <u>SCIENTIFIC VALUE</u> | <u>TECHNOLOGY IMPACT</u> | <u>FUNDING PRIORITY</u> |
|--|-----------------------------|------------------------------|-----------------------------|
| FUNDAMENTAL PHOTOELECTROCHEMICAL PROCESSES | 8-9 | 30-31 | 26-27 |
| POLYCRYSTALLINE THIN FILMS FOR PHOTOELECTRO- CHEMICAL SOLAR CELLS | 22-23 | 28 | 28 |
| PHOTOELECTROCHEMICAL CELL STABILITY | 20 | 30-31 | 26-27 |
| OTHER RESEARCH IN PHOTOELECTROCHEMICAL CELLS | 26 | 32 | 34 |
| PHOTOELECTROCHEMICAL STORAGE | 18 | 24-25 | 21 |

Support Research

| | <u>SCIENTIFIC VALUE</u> | <u>TECHNOLOGY IMPACT</u> | <u>FUNDING PRIORITY</u> |
|-----------------------------------|-----------------------------|------------------------------|-----------------------------|
| ENCAPSULANT RESEARCH | 24 | 9-10 | 16-17 |
| INSULATION RESOURCE ASSESSMENT | 30 | 24-25 | 24 |
| MEASUREMENTS AND CHARACTERIZATION | 25 | 5 | 6-7 |
| METALLIZATION RESEARCH | 22-23 | 17-18 | 16-17 |

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Systems and Modules

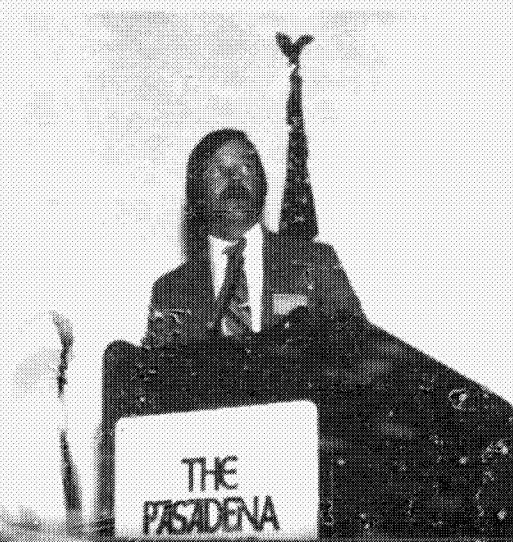
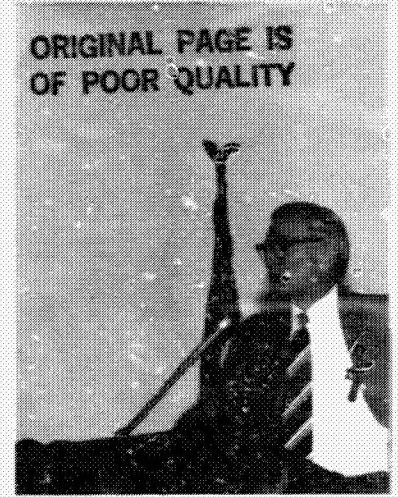
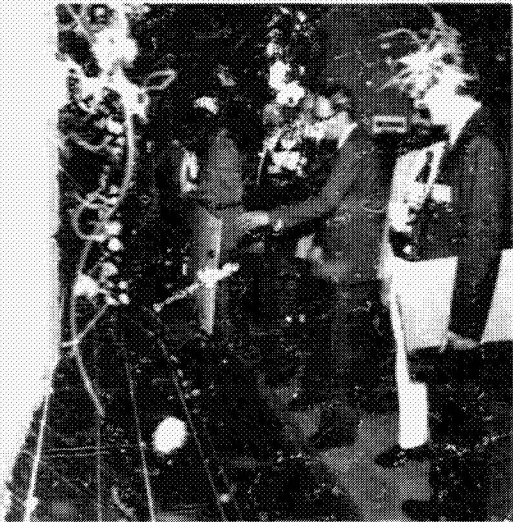
| | <u>SCIENTIFIC VALUE</u> | <u>TECHNOLOGY IMPACT</u> | <u>FUNDING PRIORITY</u> |
|--|-----------------------------|------------------------------|-----------------------------|
| FLAT PLATE MODULE RESEARCH | 34 | 13-14 | 23 |
| CONCENTRATOR MODULE RESEARCH | 33 | 23 | 25 |
| ADVANCED PHOTOVOLTAIC SYSTEMS RESEARCH | 32 | 22 | 29 |
| FRESNEL LENS RESEARCH | 35 | 27 | 33 |

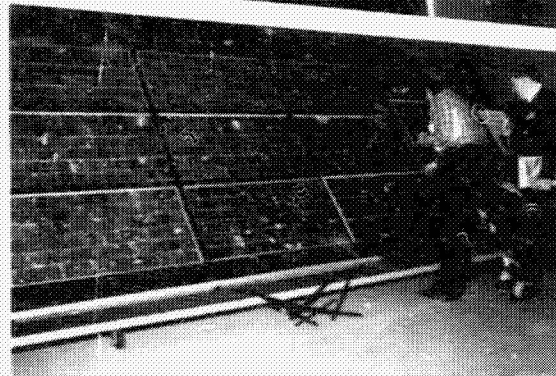
II - VI and Related Areas

| | <u>SCIENTIFIC VALUE</u> | <u>TECHNOLOGY IMPACT</u> | <u>FUNDING PRIORITY</u> |
|--|-----------------------------|------------------------------|-----------------------------|
| RESEARCH ON COPPER INDIUM DISSELENIDE (CuInSe ₂) CELL STRUCTURES AND FABRICATION | 15-17 | 11 | 9 |
| BASIC STUDIES IN COPPER INDIUM DISSELENIDE (CuInSe ₂) | 5 | 20 | 13 |
| CONTINUED RESEARCH ON CdS/Cu ₂ S | 31 | 35 | 35 |
| ALTERNATE POLYCRYSTALLINE THIN FILM PHOTOVOLTAIC MATERIALS | 7 | 26 | 18-19 |

Conclusions

- RANKINGS WERE GENERALLY CONSISTENT AMONG THE THREE GROUPS OF RESPONDEES
- "CONTRIBUTION TO BASIC SCIENTIFIC UNDERSTANDING" WAS RATED HIGHEST IN HIGH-RISK AREAS
- "POTENTIAL IMPACT ON FURTHER TECHNOLOGY DEVELOPMENT BY PRIVATE INDUSTRY" WAS ASSOCIATED WITH NEAR-TERM TECHNOLOGIES
- "PRIORITIES FOR FEDERAL AR&D FUNDING" WERE HIGHEST IN AREAS NOT WIDELY ADDRESSED BY INDUSTRY
- COPIES OF EVALUATION RESULTS ARE AVAILABLE ON REQUEST





ORIGINAL PAGE IS
OF POOR QUALITY

